USDA

United States Department of Agriculture

Cooperative State Research, Education, and Extension Service

Competitive Research Grants and Awards Management

National Research Initiative Competitive Grants Program

Annual Report Fiscal Year 1997

Knowledge For Tomorrow's Solutions

www.reeusda.gov/nri
Telephone: (202) 401-5022
E-mail: nricgp@reeusda.gov

Materials Available on the Internet

This annual report and other NRI materials, such as Abstracts of Funded Research and the 1998 Program Description, are available on the NRI home page at *www.reeusda.gov/nri.*

For more information about the NRI, write or call:

USDA/CSREES/NRICGP
STOP 2241
1400 Independence Avenue, SW
Washington, DC 20250-2241
Telephone: (202) 401-5022
nricgp@reeusda.gov

January 1998

THE NATIONAL RESEARCH INITIATIVE ON AGRICULTURE, FOOD, AND ENVIRONMENT

Annual Report
Fiscal Year 1997

The Program Concept

The National Research Initiative Competitive Grants Program (NRI) supports research on key problems of national and regional importance in the biological, environmental, physical, and social sciences relevant to agriculture, food, and the environment. The NRI facilitates a broad spectrum of research that bridges the basic and applied sciences and results in practical outcomes ensuring that U.S. agriculture and forestry are sustainable and that they remain competitive in the global arena. Competition is open to researchers at all U.S. academic institutions, Federal research agencies, private and industrial organizations and institutions, and individuals. The U.S. benefits in many ways from the creative talents of our scientists. Focusing these talents on agriculture is extremely productive, and the NRI plays a central role in making this happen.

The NRI was established in 1991 in response to a recommendation from the National Academy of Sciences in a report, "Investing in Research: A Proposal to Strengthen the Agricultural, Food and Environmental System" (National Research Council, 1989). The report recommended a major increase in funding of high priority research in order to: 1) increase competitiveness of U.S. agriculture, 2) improve human health and well-being through studies on food safety and human nutrition, and 3) enhance the environment and natural resource based upon which agriculture depends. Administration of the NRI was assumed by the former Competitive Research Grants Office (CRGO, established in 1978 as the first competitive grants program of the United States Department of Agriculture (USDA)). The National Academy of Sciences Board on Agriculture report “Investing in the National Research Initiative: An Update on the Competitive Grants Program in the U.S. Department of Agriculture” (National Research Council, 1994) and “Colleges of Agriculture at the Land Grant Universities: Public Service and Public Policy” (National Research Council, 1996) reflect the Board’s continued support of the NRI.

Scientific and technological progress is urgently needed to resolve major problems facing agriculture and forestry, which are under societal and economic pressures for change, yet must still respond to the natural hazards imposed by weather, pests, and other threats to farming and forestry. The NRI was conceived as a means of increasing the investment in areas of research with the greatest potential of expanding the knowledge base needed to solve current problems as well as meet unforseen threats to agriculture, our food supply, or the environment.

The purpose of the NRI, therefore, is to increase the amount and quality of science applied to the needs of agriculture and forestry. All U.S. scientists are eligible to compete on an equal basis for

these funds. The NRI uses scientific peers to identify the most meritorious proposals for funding each year.
Evaluation factors include scientific quality, qualifications of the investigator(s), and relevance of the proposed research to the high-priority areas identified for funding. At least 10 percent of the funds appropriated to the NRI are used for strengthening the U.S. agricultural research system through funding of seed, sabbatical, equipment, and standard strengthening grants. These awards go to postdoctoral fellows, new investigators, and scientists at small and mid-sized institutions or at institutions in EPSCoR states (Experimental Program for Stimulating Competitive Research, states that historically have been less competitive for research funds). The NRI encourages multidisciplinary research needed to solve complex problems and seeks to open new areas of science and engineering with relevance to food, agriculture, and the environment. Numerous conferences are supported to accelerate the exchange of scientific information needed for advancements in agriculture.

The NRI funds both mission-linked and fundamental research. Mission-linked research targets specific problems, needs, or opportunities. Fundamental research is the quest for new knowledge about agriculturally important organisms, processes, systems, or products and opens new directions for mission-linked research. Both mission-linked and fundamental research are essential to the sustainability of agriculture and forestry.

Authorization

Congress established the NRI with enactment of the Food, Agriculture, Conservation, and Trade Act of 1990. In Section 1615, which established this program, the "High Priority Research" to be covered was defined as basic and applied research that focuses on both national and regional research needs (and methods for technology transfer) in the following areas:

- *Plant Systems;*
- *Animal Systems;*
- *Nutrition, Food Quality, and Health;*
- *Natural Resources and the Environment;*
- *Engineering, New Products and Processes; and*
- *Markets, Trade, and Policy.*

Authorizing legislation also requires that, where appropriate, grants be consistent with the development of systems of sustainable agriculture. In authorizing funds to support the NRI, the Congress further identified percentages of available funds to be allocated for specific types of research: No less than thirty percent (30%) to support multidisciplinary team research, no less than forty percent (40%) for mission-linked research, and no less than ten percent (10%) for strengthening the research capacity of individuals and institutions.

Policy

A Board of Directors determines policy for the NRI and meets on a regular basis. It is chaired by the Under Secretary for Research, Education, and Economics, and is composed of the Administrators of the Cooperative State Research, Education, and Extension Service (CSREES), the Agricultural Research Service, the Economic Research Service, and the National Agricultural Statistics Service; the Deputy Chief for Research of the Forest Service, and the Chief Scientist of the NRI. The Deputy Administrator of the Competitive Research Grants and Awards Management Division of CSREES serves as the Executive Officer. The Board of Directors oversees NRI policy by: 1) Providing comments to the Administrator of CSREES on the annual NRI Program Description; 2) Considering recommendations made by the National Agricultural Research, Education, and Economics Advisory Board (NAREEAB); 3) Reviewing procedures for establishment of panels and any departures from the current system of merit review by scientific peers; 4) Identifying issues of importance to the NRI; 5) Providing a forum on future directions of the NRI; and 6) Fostering communication across the relevant USDA research agencies in regard to the NRI programs and procedures.

Identification of Research Needs

The research needs identified for funding by the NRI are evaluated and updated annually and made known to all universities, Federal research laboratories, private research organizations, and individual scientists through publication and Internet posting of the NRI Program Description.

The NRI is one of a portfolio of research and development activities of the USDA. Priority setting is an important activity to maximize the facilitation of scientific and technological advances urgently needed in meeting major challenges now facing agriculture in the United States. While the input from various sources serves as the basis for writing the Request for Proposals, the NRI is an investigator-initiated program; ultimately the scientific community sets forth priorities through the lines of research they propose within the framework of the program description.

Congress sets the basic framework for the NRI programs by providing funds currently in six priority funding categories. Congress also makes recommendations for the scientific and programmatic administration of the NRI through appropriation language and through questions during Congressional hearings.

The NRI scientific staff play an important role in providing continuity of programmatic and scientific administration from year to year. The staff attend important scientific and professional meetings to gain understanding of current scientific trends that need to be reflected in the NRI Program Description and coordinates priority setting with other Federal agencies. The NRI staff has also initiated commodity briefings with key representatives of the commodity groups and other user groups. These meetings are designed to provide information as to what CSREES activities relate to their area of interest, including NRI-funded research. In this way, the NRI receives comments and suggestions as to the top research priorities and on how the NRI can assist in meeting those needs. Input from several coalitions also proves to be quite beneficial because they represent a broad-based

perspective. The NRI meets with groups such as the Institute of Food Technologists, FAIR95, CROPS99, CO-FARM, and C-FARE. The NRI staff meets regularly with administrators and other university staff and often briefs ESCOP and its subcommittees and the 1890s research administrators.

The NRI scientific staff, the NRI Chief Scientist, and the CRGAM Deputy Administrator have responsibility for assimilating the extensive input from many diverse groups into a Program Description that will solicit the highest quality proposals to best meet the needs of U.S. agriculture.

The Board on Agriculture of the National Research Council (National Academy of Sciences) played a major role in formulating the NRI and maintains an active interest in its achievements. An evaluation of the NRI has recently been initiated by the Board on Agriculture. Their report will reflect an assessment of progress as well as provide perspectives for the future.

Program Execution

The Program Description is distributed widely within the scientific community and among other interested groups. The Program Description for FY 1997 was published in the Federal Register on September 30, 1996. It identified 25 research programs within eight major research areas: *Natural Resources and the Environment; Nutrition, Food Safety and Health; Animals; Pest Biology and Management*; *Plants; Markets, Trade, and Rural Development; Enhancing Value and Use of Agricultural and Forest Products;* and *Agricultural Systems Research* (funded with 2 percent of funds available for grants).

A total of 2840 proposals were considered for funding in FY 1997.

Twenty-nine peer panels reviewed and ranked these proposals. Each peer panel was constituted based on the overall expertise needed to review the submitted applications thoroughly and fairly. *Postdoctoral Fellowships*, *New Investigator Awards*, and *Strengthening Standard Research Projects* were reviewed within specified research program areas rather than by separate panels. *Research Career Enhancement Awards, Equipment Grants,* and *Seed Grants* were reviewed together by a multidisciplinary peer-review panel. Criteria for the selection of individual panel members included knowledge of the relevant scientific discipline, educational background, experience, and professional recognition in the scientific community. The membership of each panel was further carefully balanced with respect to representation of geographical regions and institutions (Table I, A & B), rank or position, gender and minority status (Table I, C & D).

In addition to the expertise brought to the process by the panel members, written reviews were solicited from scientists and other experts representing a wide variety of fields. These *ad hoc* reviews provide the additional expertise that makes it possible to select the highest quality, most meritorious proposals for funding. Over 15,000 scientists contributed their time and professional expertise to this process in 1997. Participation on the panels and in the *ad hoc* reviews provides an opportunity for many individuals to gain experience in the review process and in the nature of the

science supported by the NRI. Importantly, the pool of *ad hoc* reviewers provides a resource from which future panel members can be selected.

To complete the review process, a summary of the panel evaluation and the *verbatim* written reviews were returned to the submitting investigators. As the review process is prospective rather than retrospective, the review comments are important in providing constructive advice to improve the proposed projects. Further, those proposals not funded can be strengthened for future resubmission by taking into account the suggestions made by the reviewers.

Continuing the procedure started in 1993, non-technical summaries describing each funded research project were published in 1997 as *Abstracts of Funded Research* and submitted to the appropriations committee of both the House and Senate. This publication is also available to the public on the NRI home page.

The NRI competitive review process encourages innovative ideas intended to open fundamentally new approaches to enhancing agriculture, food, and the environment. It requires that the research address important and relevant topics and that the investigators organize and design their experimental plans in an effective manner. Importantly, the review itself provides a critical assessment of the quality of the proposals by scientists who are recognized leaders in the field.

Grants workshops are led by NRI staff to inform scientists and administrators on the philosophy and procedures of this major competitive research grants program within the USDA. The workshops included discussions on the program description, proposal preparation, evaluation criteria, and recent statistics on funding. Due to the interest in such information, the NRI holds a major grants workshop annually in one of the four regions of the U.S. (Northeast, North Central, South, and West). The FY 1997 workshop was held in the Western Region in Oakland, California, with the University of California, Berkeley serving as the co-sponsor. In addition, the NRI has provided individualized workshops at EPSCoR institutions (University of Puerto Rico, University of Arkansas, Mississippi State University, North Dakota State University and University of North Dakota) and mini-workshops at opportune venues, sponsored displays and provided personnel to answer questions at national meetings of professional societies, and made presentations to special groups such as the Congressional Fellows and the National EPSCoR Conference.

Due to the shortage of funds, the NRI did not offer the Water Resources Assessment and Protection program in FY 1997. This program will be offered in FY 1998; however, the Forest\Range\Crop\Aquatic Ecosystems will not be available. The Biological Control Research program was combined with the Assessing Pest Control Strategies program to form a new program entitled Biologically Based Pest Management.

Research Funded

The 2840 proposals considered by the NRI in 1997 requested funds totaling $591,461,591. Funding was available to award 712 grants totaling $87,315,733 which includes 5 awards totaling $1,000,000

for Water Resources and Protection proposals submitted in FY 1996 (Table II). The success rate (in numbers of proposals funded and excluding continuing increments and conferences) was 24 percent; this was the same as in FY 1995 and FY 1996. The average grant award for regular research programs (excluding Research Career Enhancement Awards, Equipment Grants and Seed Grants) was $133,379, up from $125,620 in FY 1996, with an average duration of 2.6 years, up from 2.14 years in FY 1996. If the funding of conferences and continuations is excluded, the average grant award for FY 1997 is $141,834 for 2.6 years.

There are a number of research topics of major importance to the USDA and to science that do not fall solely within an identified research area or program. The support for these "cross-cutting" subjects is indicated in Table III. The data show the total amount of funding from all research areas for a specified research topic. For example, the water quality area includes projects from the *Forest/Rangeland/Crop/Aquatic Ecosystems, Soils and Soil Biology*, and other programs in which the research was relevant to water quality. The integrated pest management area includes the projects funded from the programs on *Plant Pathology, Weed Science, Entomology, Nematology, and Biologically Based Pest Management*. The $12.6 million for sustainable agriculture represents projects identified from many NRI programs including the *Agricultural Systems Research* program as directly relevant to sustainable agriculture. This figure is probably an underestimate since virtually all research supported by the NRI is potentially relevant to sustainable agriculture in the broader sense.

In addition to the areas of science covered by the program, proposals can be examined from other perspectives such as the type of research (fundamental or mission-linked) and organization of the research approach (single discipline or multidisciplinary). Fundamental research tests scientific hypotheses and provides foundation knowledge that supports applied research. Mission-linked research may be either basic or applied, has greater near-term application, and usually targets specific opportunities or problems that need immediate solution. Another possible dimension of the research supported by the NRI is the extent to which expertise drawn from several disciplines is focused on the same scientific question. These dimensions (fundamental versus mission-linked; single discipline versus multidisciplinary) are not mutually exclusive. The amount of support in FY 1997 in these categories was:

Research Dimension	Amount of Support	Percent
Fundamental research	$45,404,251	52.1
Mission-linked research	41,711,482	47.9
Multidisciplinary research	23,321,988	26.8
Single discipline research	63,793,745	73.2

The NRI also funded approximately $15.9 million in *Agricultural Research Enhancement Awards* in FY 1997. These included individual *Postdoctoral Fellowships*, *New Investigator Awards*, and *Strengthening Awards* (Table IV).

The NRI funded several scientific meetings in FY 1997. These conferences bring together scientists in order to identify research needs, update information or advance an area of research important for U.S. agriculture. Partial support of 26 conferences was provided for a total outlay of $175,500 (average of about $6750 per conference).

Research Funded Jointly with other Federal Agencies

The NRI program directors work closely with their counterparts in other Federal agencies that fund research so as to avoid duplication and maximize cooperation. In addition, the NRI funds research jointly with other Federal agencies in three program areas. These are:

- The *Joint Program on Collaborative Research in Plant Biology*, established in 1992 with the National Science Foundation (NSF) and the Department of Energy (DOE);

- The *Terrestrial Ecology and Global Change (TECO)* program, established in 1995 with NSF, the National Aeronautics and Space Administration (NASA), and DOE; and

- The *Arabidopsis thaliana Genome Sequencing Project*, established in 1995 with NSF and DOE.

Each collaborative research program issues a single request for proposals (RFP) and assembles one panel of scientific peers to identify the most meritorious proposals. Thereafter, the NRI selects proposals from among the most meritorious but also most relevant to agriculture and within the limits of funds available.

The *Joint Program on Collaborative Research in Plant Biology* is funded from the *Plants* and the *Natural Resources and Environment* funding categories. FY 1997 NRI funds were used for continuing increments on two projects that were initially awarded in FY 1994. The *Terrestrial Ecology and Global Change* program is funded from the *Natural Resources and Environment* funding category. The NRI funded two projects in this program in 1997. The *Arabidopsis thaliana Genome Sequencing Project* is funded from the *Plants* funding category.

Presidential Early Career Awards for Scientists and Engineers

An NRI nominee received a Presidential Early Career Award for Scientists and Engineers in 1997. These Presidential Awards are intended to recognize the finest scientists and engineers who show exceptional potential for leadership at the frontiers of knowledge during the twenty-first century. This year's awardee from the NRI was Dr. Sara L. F. Sunden at the University of Illinois, Urbana-Champaign.

Dr. Sunden held research appointments at USDA/ARS/MARC and at the University of Iowa prior to her move to Illinois. Currently an Assistant Professor in the Department of Animal Sciences, Dr. Sunden received training in animal genetics at Iowa State University and at Texas A&M University.

Dr. Sunden has identified a marker gene (one that is linked to the gene of interest) for the gene resulting in a carcass condition called "acid-meat". This marker gene is also linked to the positive characteristics of tenderness and rapid growth. The ultimate goal of Dr. Sunden's research is to sort the genetic components and isolate the genes associated with each of these economically important traits.

Examples of Recent Research

Natural Resources and the Environment

Understanding how vegetation responded to environmental changes of the past may help in predicting future vegetation response to environmental change. NRI-funded research is measuring how arid grasslands responded to global changes in the past. By measuring carbon isotopes in desert soils dating back to the last glacial period (about 20,000 years ago), the research documents the dynamics between grasses (most species of which use the C4 photosynthetic pathway) and desert shrubs (most species of which use the C3 photosynthetic pathway). This information is used to determine natural cycles of desertification (general loss of grassland vegetation, which may result in desert shrub encroachment or no regeneration) in order to assess the human impact, such as grazing, on vegetation change over the last 150 years. Results are presented to federal and state agencies to help identify areas that are ecologically fragile and areas that can withstand more intensive land use.

Water limitation, such as occurs during drought, inhibits plant growth and is a major limitation to agricultural plant productivity, resulting in large economic losses. Osmotic adaptation and changes in cell wall properties have emerged as common ways in which plant cells may continue to grow when faced with a limited water supply. Research supported by the NRI showed that the adaptative response of maize roots to drought involves an increase in cell wall extensibility, partly by retention of expansins (proteins that loosen plant cell walls and enable them to enlarge). Current work is focused on molecular cloning of expansin genes from maize and assessing the involvement of these proteins in drought adaptation by this crop plant. The information could be useful for future efforts to genetically engineer maize plants for greater drought tolerance.

Researchers supported by the NRI have developed a simple, cost-effective method for bioremediation of selenium from agricultural drainage water. A media-packed pilot-scale biological reactor system inoculated with selenate-respiring bacterium *Thauera selenatis* was constructed and was used to treat agricultural drainage water containing both selenium and nitrate. Selenium oxyanion concentrations (selenate plus selenite) in the drainage water were reduced by 98%. Since denitrification also occurred in the system, nitrate and nitrite concentrations in the drainage water were also reduced by 98%. The cost to operate the reactor depended primarily on the price of the energy feed source and electricity. On a laboratory-scale, an inexpensive feed source was developed, using fermented whey.

The 1988 fires on forests in Yellowstone National Park have produced a surprising result. Seedlings of aspen, an important tree species in the northern Rocky Mountains and a species which has been in decline during this century, were found in 1989 throughout many areas of Yellowstone's burned pine forests well outside regions where aspen occurred before the fires. This was unexpected because aspen usually reproduces via sprouts rather than by seed in this region. NRI-funded research has revealed that aspen seedlings are most abundant in burned forests at lower elevations and closer to mature stands of aspen. Increased genetic diversity of aspen seedling populations compared to mature stands was also documented. Aspen in this region may regenerate by seed only after an infrequent fire event and the increased genetic diversity that results may make the population less

susceptible to changes in the environment. Understanding what contributes to the establishment of aspen following large fires can be used to define management policies of similar forested landscapes and has important implications for global climate change research and future forest dynamics.

Investigations on the transfer of pesticide biodegradation genes among soil bacteria were conducted using funds from a NRI New Investigator Award. The project's objective was to identify and characterize a genetic element that transmits biodegradation genes from a strain of *Pseudomonas aeruginosa* to other bacteria. These experiments have led to the tentative discovery of a novel mobile element that carries genes for pesticide decomposition reactions as well as genes that pump pesticides into bacteria. Further research on this element will provide confirmatory evidence of these functions, identify other genes it might transmit, and determine the transfer mechanism(s) between different bacteria. These studies will also provide insight into bacterial evolution, better utilization of microbes for clean-up of contaminated soils, and improved knowledge of possible gene escape routes needed for risk assessment of genetically engineered microorganisms in the environment.

Enhancing Value and Use of Agricultural and Forest Products

Knowledge of wood surface chemistry is of prime importance for the understanding of wood adhesion; wood is adhesive-bonded in 70% of all its applications. Much of the impetus for wood surface chemistry research is the result of problems that occur when bonding both aged and over-dried wood in commercial adhesive applications. Surface changes in wood resulting from various processing treatments were monitored using dynamic contact angle (DCA) and X-ray photoelectron spectroscopy (XPS) analyses in an NRI-funded project. Results indicate that the wood surface behaves like other polymer surfaces (such as adhesives) when exposed to changes in external environments. This reinforces the role of extractives in influencing wood surface chemistry; preferential molecular orientation and reorientation of the extractives will occur depending on the environmental conditions to which the wood is exposed. With this information, an adhesive chemist can optimize an adhesive by taking advantage of secondary mechanisms resulting from wood's own adhesion regions.

Research is being supported by the NRI to determine the effects of oxygen and carbon dioxide on quality maintenance of fresh-cut fruits, a rapidly growing segment of the U.S. produce. The research will determine the effects of oxygen and carbon dioxide concentrations on fruit tissue browning and associated changes in phenolics and polyphenol oxidase activity following slicing and identify optimal atmospheric composition for apple, pear, peach, persimmon, kiwi, and strawberry when lightly processed to maintain their appearance, textural, flavor, and nutritional quality between preparation and consumption. To date, researchers have examined treatments that significantly extend shelf life of Bartlett pears without off-flavors or odors. Atmospheric modifications have been similarly demonstrated for kiwi and pomegranates. The knowledge gained in this project will be used to optimize packaging and handling of fresh cut fruits resulting in increased availability of fresh cut fruits for consumers and expanded markets for producers.

Researchers supported by the NRI are developing a versatile family of biodegradable polymer/surfactants for use in high-volume applications such as cleaners for oil removal and/or as potent emulsion stabilization agents. These amphiphilic polymers will be made from abundant agricultural sources including polysaccharides, fatty acids, citrate and succinate. In particular, researchers are examining the structure-property relationships of these new polymers such that properties can be optimized for the intended application. The researchers have determined the most effective means of preparing a wide range of starch-fatty acid ester derivatives and have initiated biodegradable studies of these products. Use of renewable agricultural products in place of petroleum, more environmentally sound manufacturing, and less toxic and biodegradable end products are among the potential benefits of this research.

The cost and maintenance of machinery used in the manufacturing of wood composites amounts to millions of dollars per year. These costs are likely to increase in the future due to shortages of certain metals, such as cobalt, which is used in high speed steel cutting tools. Research funded by the NRI shows that chlorine and sulfur anionic components in wood products promote high temperature oxidation/corrosion of tool materials in wood machinery. Reduction of this tool wear has been accomplished by formulating binder resins with lower levels of chlorine and sulfur anionic components and with other anionic components.

In a multidisciplinary project, researchers supported by the NRI are seeking to lay the foundation for recovering high-value agricultural products from transgenic plants. The long-term goal is to develop an approach that is adaptable to a wide variety of recombinant proteins while allowing the co-production of traditional seed products. To establish the approach, researchers are examining recovery of model enzymes from transgenic soybeans. Specific aims of the project are: (1) to determine which steps in the soybean processing are most likely to affect the yield of recombinant proteins; (2) to modify process parameters and to evaluate the effect of these modifications on the yield of co-products; and (3) to evaluate the recovery enhancement which can be obtained by employing charged tails combined with ion-exchange and polyelectrolyte precipitation for model proteins spiked into soy extracts. Researchers have obtained the transgenic soybeans and have determined the effects of soybean processing parameters on the enzyme stability, the first step needed to define the parameters to preserve optimal enzyme activity.

Plants

The nutritional quality of corn can be dramatically improved by altering a regulatory gene that controls expression of kernel storage proteins called zeins. Zeins have low levels of two essential amino acids, lysine and tryptophan. Unfortunately, corn breeding lines with the regulatory gene of interest have poor seed quality. To correct these deficiencies, breeders have introduced modifier genes into breeding stocks which condition a hard endosperm while maintaining high levels of lysine and tryptophan, known as Quality Protein Maize (QPM). Scientists funded by the NRI have identified molecular markers linked to QPM modifiers in corn. This knowledge could be integrated directly into corn breeding programs to accelerate the development of inbred hybrid QPM's for U.S.

agriculture. Widespread adoption of QPM in the U.S. would increase the nutritional value of corn products by avoiding the use of costly supplements.

The recent discovery of the Green Fluorescent Protein (GFP) from the jellyfish *Aequorea victoria* has revolutionized research in cell, molecular, and developmental biology because GFP is non-invasive and allows visualization of biochemical events in living cells. Various versions of GFP have provided breakthroughs in our understanding of such processes as gene expression, protein-protein interactions, and protein secretion. However, GFP emits light only in the blue and green regions of the spectrum. NRI-funded research to study the synthesis of the pigment (chromophore) associated with phytochromes, a family of plant light-receptors, resulted in the discovery of a new class of fluorescent molecules called phytofluors that can be produced in many living cells allowing scientists to view the cells' activities "from the outside." When taken up by the cells, phytofluors spontaneously assemble into markers that produce light in the orange and red part of the spectrum. This range of light is potentially very important, as it eliminates some of the technical difficulties that limit GFP application. This result indicates that fundamental research can often lead to the discovery of tools that have broad applications in science and technology.

Almost all the oxygen in the atmosphere is produced as a by-product of water oxidation when plants and algae utilize energy from sunlight to convert carbon dioxide to biomass. The atoms and molecules found in the plant's photosynthetic apparatus, which are sites of these reactions, are thus not only the basic farm machinery, but also primary generators of our oxygen. The scientists funded by the NRI have now been able to form a model of how these molecules split water while at the same time forming and evolving oxygen gas. In addition to explaining how oxygen is evolved in plants, this model also explains how the plant has developed mechanisms to avoid and protect itself from potentially damaging, high energy free radicals. Although the plant has developed mechanisms which protect the delicately tuned photosynthetic apparatus, environmental extremes of today's world in temperature, carbon dioxide concentration and water availability still cause perturbations in photosynthesis and oxygen evolution that affect agricultural production.

Nitrate, the nitrogen compound formed as a result of nitrogen fixing symbiosis in legumes or via fertilizer application to other crop plants, is used by the plant to form amino acids, which are the building blocks of plant proteins and other compounds. Scientists supported by the NRI are investigating how nitrate assimilation (which occurs in leaves in the light, but not in the dark) is controlled. They have found that activity of the enzyme that catalyzes the first step in nitrate assimilation is controlled by reversible attachment of a molecule containing phosphorus and by another protein which was first identified in brain tissue. Nitrate is a limiting factor in crop production. To maximize yields, fertilizer nitrates are frequently applied in quantities that exceed the crop's ability to absorb and assimilate and the excess nitrate becomes a serious threat to ground and surface water supplies. Understanding how plants utilize nitrate and how utilization is controlled is likely to open the way to manipulation of assimilation pathways in crops as well as to development of precision agriculture techniques for fertilizer application.

Pest Biology and Management

Researchers have begun to genetically engineer soybean plants that kill several caterpillars which are important soybean pests. NRI-funded research has demonstrated that a synthetic form of *Bacillus thuringiensis* was widely expressed in soybean leaves. In the genetically altered soybeans, the proportion of leaves chewed upon by these caterpillars was less than 4%. In contrast, soybeans that were not genetically altered suffered up to 40% damage by the caterpillars. The bacterial insecticide produced is completely safe to mammals. This research will potentially reduce or even eliminate the need to spray environmentally toxic insecticides to control these caterpillars.

Aflatoxins are toxic and carcinogenic secondary metabolites produced by *Aspergillus flavus* on several important food sources. Researchers funded by the NRI have been working toward understanding the biosynthetic pathways and regulatory elements involved in aflatoxin biosynthesis, with the ultimate goal of developing novel control strategies. A regulatory gene specific to this pathway (*afl*R) was cloned and characterized. Constitutive expression of the protein (AFLR) coded by this gene leads to increased transcription of the aflatoxin pathway genes and upregulation of aflatoxin biosynthesis. Factors other than AFLR were also found to be involved in aflatoxin regulation. The *afl*J gene, which is located next to *afl*R is also involved in aflatoxin biosynthesis. When *afl*J is disrupted, *A. flavus* does not produce aflatoxin from its pathway intermediates.

Eighty-five percent of the total pesticides applied to croplands in the United States are herbicides for weed control. Researchers funded by the NRI are trying to reduce the need for use of herbicides against weeds of winter wheat by developing varieties of wheat that are more competitive against common weeds in wheat fields. They are finding that total leaf area and rapid early growth are important traits contributing to better competitiveness of wheat in a normal rainfall year. In a dry year, rapid early growth combined with earlier maturation are important.

In nature, moth insects commonly use chemical signals to find potential mates to breed. Entomologists have broken the chemical code for the Pink Bollworm Moth, and are able to manufacture its chemical signal synthetically. Researchers with NRI funding have discovered how to make it difficult for male moths to find female mates by releasing these chemicals at different dosages and different frequencies in a laboratory setting. It is hoped that use of this chemical, which only will affect the sexual behavior of this species of moths, will ultimately be used in cotton fields to reduce egg laying activity by female moths, thereby reducing the need for pesticides.

Markets, Trade, and Rural Development

Agricultural economists improved an international trade model with NRI funds by incorporating a hitherto missing link, namely the integration of the impact of rapid manufacturing growth upon food imports. This improvement allowed them to verify that trade is definitely a “two way street.” What they discovered was that the MultiFiber Agreement (MFA), which restricts imports of manufactured fiber products and textiles into North America, had indirect impacts on NAFTA’s potential level of exports. The failure to fully reform the MFA will force more labor and capital into the Asian-4

nations (Thailand, Malaysia, Indonesia, and the Philippines) food and agricultural sectors resulting in net exports of $7.7 billion from these nations, while NAFTA's exports of food items to these nations will drop by over $1 billion. This effort makes abundantly clear that imposing trade restrictions in one sector of the economy can have dire consequences in another.

The fresh produce industry, particularly for melons, lettuce and tomatoes, is highly competitive. Combinations of strategies can result in competitive advantages. In NRI-supported research, executives of 81 firms that are responsible for 80 percent of the lettuce, 75 percent of the tomatoes, and 60 percent of the melons that are shipped annually were interviewed to determine how successful firms respond to pressures resulting from competition. Developing strategic alliances between growers or purchasing land in many north-south areas results in being able to produce, process, and ship fresh produce nearly year round in many cases. This strategy is even more tenable with decreases in trading barriers (such as NAFTA). Taking advantage of genetically improved seed stocks designed for specific micro-climates results in increased yields and quality characteristics that enhance competitiveness and therefore developing strategic locational alliances results in spreading operational overhead and the costs of professional staff over many more months and over many more units of production. Decreasing costs enhance competitive positions.

Do business incubators in rural areas contribute jobs and increased income levels as a result of new or improved businesses? NRI-funded rural sociologists measured the impacts of business incubators and the associated costs to the public with startling results. At the end of a seven year period, total impacts from the incubator firms were an estimated 563 jobs and $10,588,000 payroll. The range in costs per job created varied from $6,000 - $8,400, but when compared to the costs associated with industrial recruitment, $11,000 - $50,588 per job, it was obvious that business incubators are a real deal. The net effect is a significant economic development boost to rural areas development.

Nutrition, Food Safety and Health

NRI-funded research has shown that varying the level of dietary protein strongly influences calcium homeostasis and bone turnover in adult women. Studies in healthy adult women consuming diets either low or high in protein exhibited abnormalities in calcium and bone metabolism, which was not observed in those on a medium protein diet. At high levels of protein intake intestinal calcium absorption is normal but bone resorption is increased which results in hypercalciuria and bone loss. Whereas, at low dietary protein levels, intestinal calcium absorption is depressed and secondary hyperparathyroidism develops, accompanied by hypocalciuria and reduced bone turnover. Impaired intestinal calcium absorption combined with reduced bone turnover may result in a diminished incorporation of calcium into bone. Abnormalities in calcium and bone metabolism could lead to decreased bone mass and/or increased fracture risk. These studies suggest that the Recommended Dietary Allowance (RDA) for protein may need to be re-evaluated.

Outbreaks of *E. coli 0157:H7* have been associated with consumption of contaminated apple cider. Research is being funded by the NRI to develop processes that will eliminate *E. coli 0157:H7* from cider without adversely affecting flavor. *E. coli 0157:H7* exhibited little resistance when heated in

ciders and it was shown that heat resistance varies with apple variety. A relatively mild heat treatment was necessary to eliminate *E. coli*, and the heat treatment could even be lowered with the addition of benzoic acid.

Animals

Mycoplasma gallisepticum (MG) is a respiratory pathogen of poultry. MG infection is commonly known as chronic respiratory disease (CRD) in chickens, and infectious sinusitis in turkeys. MG causes severe economic loss, mostly due to the need to eradicate infected breeder flocks before they infect progeny. MG infections in domestic poultry production have been difficult to control due to problems in diagnosis and vaccination. NRI-supported research resulted in the development of an improved MG diagnostic test. This test, using the polymerase chain reaction (PCR), allowed the detection of MG in tracheal samples within 24 hours. This is an improvement over traditional cultural methods that require several weeks to complete.

An ongoing NRI-funded project has produced an altered channel catfish virus that may eventually be used as the basis for a vaccine. The candidate vaccine virus is 100 times less lethal than the wild virus, and it grows in the same tissues, the gills and skin, as the wild virus. Infection with the candidate vaccine virus immunizes catfish against infection and subsequent death caused by the wild-type virus. Since outbreaks of channel catfish virus disease can result in 95% mortality of catfish fingerlings, a vaccine would be of great benefit to the aquaculture industry.

Enterocytozoon salmonis is a parasite that causes mortality among several species of salmonid fish. Research funded by the NRI has shown that the development of *in vitro* techniques, central to the understanding of many intracellular pathogens, are possible for the fish microsporidia. Using these newly developed tools, this project has made major strides towards understanding how the parasite causes disease in its host, how it might be treated or prevented, and it has aided in development of sensitive and specific detection tests. A powerful diagnostic tool was developed in the battle to determine how the parasite is transmitted and spread among salmonid populations. This test, based on the polymerase chain reaction, is becoming the standard for screening of adult salmon and trout adults which serve as egg supplies for export.

NRI-funded research focuses on designing more effective methods to cryopreserve spermatozoa from livestock. Addition of liposomes composed of phosphatidylserine and cholesterol to the cryopreservation media protected both bull and stallion spermatozoa from cold shock and freeze-thaw damage resulting in a 10% increase in the percentage of motile sperm when compared to cryopreservation techniques not utilizing liposomes. Artificial insemination of mares with stallion spermatozoa frozen in the presence of liposomes resulted in fertility rates 33% higher than spermatozoa cryopreserved without liposomes. Studies are currently in progress to determine if liposomes will prove effective in cryopreserving poultry spermatozoa, an agriculturally important species for which cryopreservation of spermatozoa is unsatisfactory for commercial use. Efficient methods to cryopreserve rooster spermatozoa would improve the genetics of breeding animals,

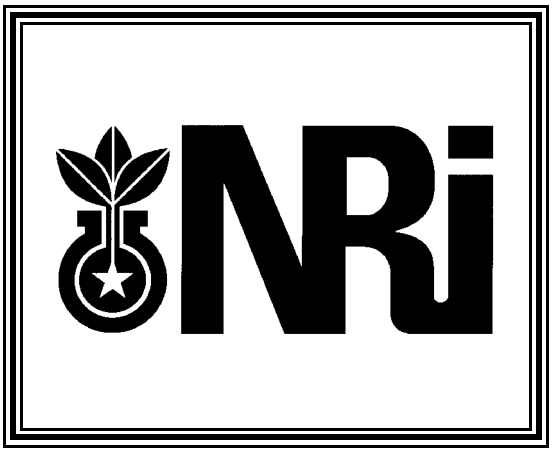
control the spread of disease, preserve unique gene pools and save the poultry industry more than $25 million annually.

In cattle, 30-40% of pregnancies are lost during the first 40 days of gestation. Research funded by the NRI has identified a protein, interferon-tau, which is produced by the developing embryo prior to implantation. Interferon-tau acts as a biochemical signal to the mother's uterus to establish pregnancy in cattle and sheep. Genes encoding interferon-tau have been identified and characterized from cattle and sheep. Recombinant bovine and ovine interferon-tau, when given to nonpregnant cattle or sheep, extended the length of the reproductive cycle. Current studies are investigating the potential use of recombinant interferon-tau as a fertility drug to minimize early embryonic losses associated with insufficient embryonic production of interferon-tau in livestock.

NRI-funded researchers have identified a genetic marker for Spider Lamb Syndrome (SLS). A genetic marker allows the detection of differences between normal and carrier animals. A blood sample is taken from the animal and sent to a laboratory. Test results allow the producer to determine which animals to maintain for breeding purposes. Identification of carrier animals will allow elimination of the spider gene from breeding flocks within a single generation.

Agricultural Systems Program

Three goat breeds (Tennessee Stiff-Legged, Spanish, and Boer) were crossbred and fed diets of varied nutritional content in NRI-supported research. Results indicate that the Tennessee Stiff-Legged goat is capable of passing on its high meat-producing gene to its crossbred progeny, despite their comparative small size. Boer goats had faster growth rates than the other breeds when nutrition was not a limiting factor. All breeds demonstrated increased potential for growth given ample nutrition. This information and future results will be used to develop equations that relate lean and fat growth to physiological maturity of goats and to refine the Texas A&M goat simulation model, improving its use across production systems. The developed model could be applied to different geographical locations of the world with minimal investments of resources by inserting different production parameters.



Tables

TABLE I

Distribution of NRI Panel Membership
Fiscal Year 1997

A. Distribution by Geographical Region

Area	Number	Percentage
Northcentral	91	28.8
Northeast	57	18.0
South	84	26.6
West	84	26.6

B. Distribution by Institution Type

Institution	Number	Percentage
Land-Grant	203	64.3
Public/Private	56	17.7
Federal	37	11.7
Industry/other	20	6.3

C. Distribution by Academic Rank

Rank	Number	Percentage
Assistant Professor	63	20.0
Associate Professor	81	25.6
Professor	106	33.5
Federal/Industry/other	66	20.9

D. Distribution of Women and Minorities

Classification	Number	Percentage
Nonminority males	209	66.1
Nonminority females	72	22.8
Minority male/female	35	11.1

TABLE II
Fund Allocations for NRI[1]
Fiscal Year 1997

Research Area/Program	Number of Grants	Total Dollars Awarded
NATURAL RESOURCES & ENVIRONMENT		
Plant Responses to the Environment	28	$3,529,368
Forest/Rangeland/Crop/Aquatic Ecosystems	18	3,849,068
Water Resources Assessment and Protection[2]	5	1,000,000
Soils and Soil Biology	18	3,652,413
Total: Natural Resources and the Environment	69	12,030,849
NUTRITION, FOOD SAFETY, & HEALTH		
Improving Human Nutrition for Optimal Health	29	3,553,629
Ensuring Food Safety	20	2,506,102
Total: Nutrition, Food Safety, & Health	49	6,059,731
ANIMALS		
Enhancing Animal Reproductive Efficiency	27	4,467,279
Sustaining Animal Health and Well-Being	60	9,434,059
Identifying Animal Genetic Mechanisms and Gene Mapping	17	3,174,857
Improving Animal Growth and Development	19	2,948,974
Total: Animals	123	20,025,169
PEST BIOLOGY AND MANAGEMENT		
Entomology	55	5,464,500
Nematology	7	643,569
Plant Pathology	39	4,407,000
Biologically Based Pest Management	11	1,628,708
Weed Science	8	935,000
Total: Pests, Biological Control, and Integrated Pest Management	120	13,078,777
PLANTS		
Plant Genome	28	5,101,566
Plant Genetic Mechanisms	37	4,191,886
Plant Growth and Development	53	5,133,666
Nitrogen Fixation/Nitrogen Metabolism	24	2,374,466

TABLE II Fund Allocations for NRI[1] Fiscal Year 1997		
Photosynthesis and Respiration	16	1,857,000
Total: Plants	158	18,658,584
MARKETS, TRADE, & RURAL DEVELOPMENT		
Markets and Trade	20	1,699,000
Rural Development	11	1,590,000
Total: Markets, Trade, & Rural Development	31	3,289,000
ENHANCING VALUE AND USE OF AGRICULTURAL AND FOREST PRODUCTS		
Food Characterization/Process/Product Research	21	2,983,485
Non-Food Characterization/Process/Product Research	16	2,385,916
Improved Utilization of Wood and Wood Fiber	24	2,307,756
Total: Enhancing Value & Use of Agricultural & Forest Products	61	7,677,157
OTHER		
Agricultural Systems	10	1,883,307
Strengthening Programs	86	3,390,162
Joint Program on Collaborative Research in Plant Biology - Interagency	2	135,331
Terrestrial Ecology and Global Change - Interagency	2	887,666
Arabidopsis thaliana Genome Sequencing Project - Interagency[3]	1	200,000
Total: Other	101	6,496,466
GRAND TOTAL	712	87,315,733

[1]The content of this table varies slightly from tables provided in documents supporting the President's budget to Congress each year. Awards are arranged in this table under program area (to which proposals are submitted and reviewed) as opposed to relationship to appropriated budgetary lines.
[2]Proposals submitted in FY 1996.
[3]Awarded through an interagency transfer to the National Science Foundation.

TABLE III

Crosscutting Program Areas
Fiscal Year 1997

Research Topic	Number of Grants	Total Dollars Awarded
Plant Genome	86	11,129,483
Forest Biology	44	5,871,794
Global Change	71	11,643,250
Sustainable Agriculture	97	11,931,879
Animal Genome	15	2,984,857
Animal Health	80	11,101,288
Water Quality	26	3,956,678
Food Safety	31	3,869,539
Integrated Pest Management	80	8,875,961

TABLE IV

Agricultural Research Enhancement Awards
Fiscal Year 1997

Type	Number of Grants	Total Dollars Awarded
Postdoctoral Fellowships	27	2,362,726
New Investigators	35	4,191,525
Strengthening Awards		
Career Enhancement Awards	6	352,846
Equipment Grants	38	1,019,886
Seed Grants	42	2,017,430
Standard Strengthening Awards	50	6,733,759